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(54) **Use of steel-pipes having an organic resin outer surface coating for improved hydroforming**

Verwendung von mit organischem Harz aussenflächenbeschichteten Stahlrohren für verbesserte Innenhochdruckumformung

Utilisation des tubes en acier à surface extérieure revêtue de résine organique pour un hydroreformage amélioré

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(73) Proprietor: **SUMITOMO METAL INDUSTRIES, LTD.**
Osaka-shi, Osaka 541-0041 (JP)

(72) Inventors:
- **Kojima Masayasu**
  Hyogo 665 (JP)
- **Ikisima Kenji**
  Hyogo 651-21 (JP)
- **Tomiyasu Ken**
  Hyogo 663 (JP)

(74) Representative: **Woods, Geoffrey Corlett et al**
J.A. KEMP & CO. Gray's Inn 14 South Square
London WC1R 5JJ (GB)

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Description

[0001] The present invention relates to the use of a lubricant surface-treated pipe in hydroforming, which pipe has excellent lubrication for hydroforming.

[0002] Hydroforming, of a steel pipe is known as a typical method for forming T-shaped pieces (hereinafter referred to as T pieces) to be used at branches of piping.

[0003] Drawings will be referred to for explaining the general structure of T pieces and conventionally-recognized problems.

[0004] Figs. 1A and 1B show a T piece, wherein Fig. 1A shows a side view and Fig. 1B shows a sectional view taken along line A-A of Fig. 1A. A T piece 1 includes a trunk 1a and a branch 1b, having a height H, which merge together through a crotch 1c, having a smooth curvature (radius R).

[0005] Figs. 2A and 2B show dies used for hydroforming a T piece, wherein Fig. 2A shows a longitudinal sectional view and Fig. 2B shows a side view. Dies 2 include an upper die 2a and a lower die 2b which are vertically separable from each other.

[0006] A semicircular groove 2a-1 is formed in the upper die 2a, whereas a semicircular groove 2b-1 and a hole 2b-2 are formed in the lower die 2b. The shape of the thus-formed die cavity is identical to the profile of the T piece 1. The dies 2 are generally of a tool steel. The surface of the die cavity is smoothly finished and is hardened through heat treatment or chromium-plating.

[0007] Figs. 3A to 3D show the steps of hydroforming a T piece.

[0008] In a step shown in Fig. 3A, a tubular blank 3, having a predetermined length L_0 is set in the dies 2 of a hydroforming machine (not shown). An outer diameter D1 and a wall thickness t_a of the tubular blank 3 are identical to those of a product T piece. A tubular blank is a short piece of pipe obtained by cutting a long steel pipe into pieces, each having such a length as to be accommodated in the hydroforming dies. The tubular blank 3 is set in the groove 2b-1 of the lower die 2b, and then the upper die 2a attached to the vertically pressing apparatus of a hydroforming machine (not shown) is lowered, thereby setting the tubular blank 3 in the dies 2. In order to hold the upper die 2a in position during hydroforming, the upper die 2a is pressed against the lower die 2b by a predetermined force.

[0009] In a step shown in Fig. 3B, opposed pushing blocks 4 and 5 attached to the horizontally pressing apparatus of a hydroforming machine (not shown) are advanced to press the end surfaces 4a and 5a thereof against the end surfaces 3a of the tubular blank 3. Then, the tubular blank 3 is filled with a hydraulic fluid 8 injected through a hydraulic fluid path 6. The hydraulic fluid is usually of an emulsion prepared through combination of water with oil, which oil is intended primarily for rust prevention. Subsequently, while the pressure of the hydraulic fluid 8 is increased, the pushing blocks 4 and 5 are advanced. As a result, the tubular blank 3 begins to deform along the round (R) portion 2b-3 of the hole 2b-2 of the lower die 2b, so that part of the tubular blank 3 begins to project into the hole 2b-2.

[0010] In a step shown in Fig. 3C, the tubular blank 3 is contracted to a length L' slightly longer than the length of the trunk of a product T piece, and a projected portion 9b is formed against the hole 2b-2 and a stopper 7 set in a predetermined position. Thereafter, the pressure of the hydraulic fluid 8 is reduced, the pushing blocks 4 and 5 are retreated, and the upper die 2a is raised. The stopper 7 is raised by a cylinder (not shown) to thereby eject a semifinished product 9 from the lower die 2b.

[0011] Fig. 3D shows a side view of the semifinished product 9. The projected portion 9b is cut at a height H, and a trunk 9a is finished to a length L, followed by heat treatment, as needed, to thereby obtain a T piece.

[0012] In the steps shown in Figs. 3A to 3C, the hydraulic fluid 8 applies to the tubular blank 3 a pressure ranging from hundreds of atmospheres to one thousand and several hundreds of atmospheres. In addition, the pushing blocks 4 and 5 apply a compressive force to the tubular blank 3. Accordingly, a high pressure acts on the outer surface of the tubular blank 3 and the groove 2a-1 of the upper die 2a and the groove 2b-1 of the lower die 2b.

[0013] Also, a high pressure acts on the R portion 2b-3 of the hole 2b-2 of the lower die 2b along which the work-hardened tubular blank 3 slides. Under these circumstances, the following problems arise in association with the friction induced between the tubular blank 3 and the die surface when the tubular blank 3 is compressed in an axial direction in the die grooves 2a-1 and 2b-1, or when part of the tubular blank 3 projects into the die hole 2b-2.

[0014] First, scratches are formed in the outer surface of the semifinished product 9, and these must be removed by polishing with a grinder or the like. As mentioned previously, the cavity of the dies 2 is finished hard and smooth. However, since hydroforming involves severe friction, repeated hydroforming results in the formation of scratches even in the dies 2. Correction of the die surface through polishing reduces production efficiency, and repeated correction results in a change of dimensions of a product. In such a case, the corrected portion of the die surface must be padded and finished, resulting in an increase in maintenance cost.

[0015] Second, since the tubular blank 3 is difficult to slide in an axial direction, the tubular blank 3 is likely to buckle in the vicinity of end portions thereof. Thus, hydroforming a thin-walled product is difficult.

[0016] Fig. 4 shows a buckled tubular blank 3. As shown in Fig. 4, buckling 10 is likely to occur in the vicinity of end portions of the tubular blank 3.

[0017] Third, since part of the tubular blank 3 becomes difficult to project into the die hole 2b-2, the projected portion 9b is likely to crack.

[0018] Fig. 5 shows the cracked projected portion 9b. As shown in Fig. 5, a crack 11 occurs in the top area of the projected portion 9b when the tubular blank 3 becomes difficult to project into the die hole 2b-2.

[0019] In solving the above problems involved in hydroforming, it is important to reduce frictional resistance involved in sliding motion between a tubular blank and dies under a very high surface pressure.

[0020] In order to reduce such frictional resistance, the outer surface of a tubular blank is treated against galling to the die surface. A lubrication oil may be applied onto the outer surface of a tubular blank, but this method is relatively ineffective because the lubrication oil is rubbed off due to sliding under a high surface pressure between the tubular blank and the dies. Also, a water-based hydraulic fluid used for applying an internal pressure to a tubular blank accommodated in dies may deteriorate the effect of a lubrication oil.

[0021] Accordingly, anti-galling paint is commonly employed. A tubular blank obtained by cutting a pipe to a predetermined length is degreased and then paint is applied on the outer surface thereof by spraying or brushing. After the applied paint is sufficiently dried and solidified, hydroforming is performed.

[0022] However, this method involves the following problems.

[0023] First, the degreasing and painting of a tubular blank require corresponding labor or man-hours. Since painting a long pipe it is difficult, the pipe is cut into tubular blanks, each having a predetermined length, and then each of the tubular blanks is painted. In this case, the step of cutting a pipe into tubular blanks cannot be continuously linked to a hydroforming step. Accordingly, material stagnates between steps, requiring an excess space for storing material and impairing the overall efficiency of a hydroforming system.

[0024] Second, since each of the tubular blanks, which are cut into a predetermined length from a long steel pipe, is painted by hand, such painting requires not only painting time, but also skill to paint the curved surface of a tubular blank to a uniform thickness. In the case of a thin-walled tubular blank, if the painting thickness is nonuniform, the tubular blank will be highly likely to buckle at a portion where the painting thickness changes, while being compressed in a longitudinal direction thereof during hydroforming. When the coating of paint is excessively thick, the coating of paint will adhere to the die surface. Such adhering paint will dimple on the surface of a product in the next hydroforming process. Accordingly, upon completion of hydroforming, such adhering paint must be removed before the next hydroforming process starts, thus wasting time and labor.

[0025] Third, in painting, paint is likely to adhere thick to part of the end surface of a tubular blank. This may disable sealing at the end surface of a tubular blank when a hydraulic fluid is injected into the tubular blank for hydroforming as shown in Fig. 3C. Accordingly, before hydroforming is started, the end surfaces of a tubular blank must be visually checked, and any adhering paint must be removed therefrom.

[0026] Fourth, when the coating of paint must be removed through use of an organic solvent after hydroforming is completed, much labor and time is required. Also, a problem in working environment may arise.

[0027] JP-A-59 029 147 discloses a steel pipe whose outer surface is primed with anticorrosive powdered epoxy resin and coated with urethane resin. The urethane resin improves flexibility.

[0028] US 4,510,007 discloses a method of jacketing pipes comprising applying a blend of an epoxy resin and a curing agent to the pipe.

[0029] EP-A-0 357 508 discloses a water-dispersion-type hot-rolling lubricant for use in coating a mandrel bar which is used to produce seamless steel pipes.

[0030] In view of the foregoing, an objective of the present invention is to provide a lubricant surface-treated steel pipe for hydroforming use characterised in the following.

a) A long pipe whose surface is coated with a resin. Accordingly, hydroforming can be started immediately after the long pipe is cut into tubular blanks.
b) Galling is effectively prevented, and excellent lubrication is provided.
c) Through selection of an appropriate type of resin coating, the coating may be utilized intact or may be removed after hydroforming, as needed. Coating can be readily removed through alkaline degreasing.

[0031] To achieve the above objective, the present invention provides:

1) Use of a lubricant surface-treated steel pipe in hydroforming, which pipe comprises a steel pipe and a lubricating organic resin coating provided on at least an outer surface of the steel pipe, the coating having a thickness of 1 μm to 100 μm; and
2) Use of a lubricant surface-treated steel pipe in hydroforming, which pipe comprises a steel pipe, a pre-treatment layer provided on at least an outer surface of the steel pipe, and a lubricating organic resin coating provided on the surface treatment layer, the coating having a thickness of 1 μm to 100 μm.

Fig. 1A is a side view showing a T piece;
Fig. 1B is a sectional view taken along line A-A of Fig. 1A;
Fig. 2A is a longitudinal sectional view showing dies used for hydroforming a T piece;
Fig. 2B is a side view showing the dies of Fig. 2A;
Fig. 3A is a partial sectional view showing a step of hydroforming a T piece;
Fig. 3B is a partial sectional view showing a step of hydroforming a T piece;
Fig. 3C is a partial sectional view showing a step of hydroforming a T piece;
Fig. 3D is a side view showing a semifinished T piece;
Fig. 4 is a partial sectional view showing a buckled tubular blank; and
Fig. 5 is a perspective view showing a semifinished product whose projected portion is cracked.

[0032] Limiting conditions for a lubricant surface-treated steel pipe for hydroforming use of the present invention will now be described in detail.

(a) Organic resin coating (hereinafter referred to as a resin coating)

[0033] The present inventors have found that using a resin coating as a lubricant is an optimum way to cope with severe sliding conditions between dies and an object material in hydroforming.
[0034] In order to prevent galling, scratches, buckling, cracking, and similar problems in hydroforming through attainment of appropriate lubrication, a resin coating is provided on at least the outer surface of a steel pipe. This coating functions as a spacer to prevent the direct metal-to-metal contact between dies and a steel pipe.
[0035] The resin coating is left on the surface of the hydroformed product after hydroforming and is called a non-removal resin coating.
[0036] The organic resin to be used for the non-removal resin coating may be of the thermosetting or radiation curing type. The organic resin is selected from acrylic, urethane, polyester, and epoxy resins. These resins may be cross-linked through use of an appropriate crosslinker. Examples of a crosslinker include amino resins and epoxy resins. Also, an acrylic resin prepared through polymerization primarily of acrylic acid and methacrylic acid may be thermoset through the use of methyl alcohol- or butyl alcohol-modified melamine.
[0037] The organic resin coating used in the present invention may contain additives such as lubricants, pigments, and rust preventives in order to improve the physical properties thereof.
[0038] A resin coating must have pressure resistance and adhesion. In hydroforming, the surface pressure between an object material and dies may reach thousands of atmospheres. The pressure resistance of a coating is evaluated in terms of hardness. It is desirable for a resin coating to have pencil hardness H or higher as specified in JIS K5400-6.14. In hydroforming, working heat and frictional heat cause the surface temperature of an object material to rise. Usually, the surface temperature of a carbon steel pipe rises to approximately 40°C to 60°C, and that of a stainless steel pipe rises to approximately 70°C to 90°C. As mentioned previously, an emulsion is used as a hydraulic fluid, so that water is present between the dies and the object material. Accordingly, a coating must maintain adhesion in a heated moist state.
[0039] Generally, a resin coating, which is primarily formed from high polymers, decreases in modulus of elasticity and adhesion at high temperatures. Particularly, at a temperature not lower than a glass transition temperature, these properties deteriorate significantly. Accordingly, the glass transition temperature of the resin coating is 40°C or higher.
[0040] However, if the glass transition temperature of a resin coating is excessively high, the resin coating may crack during hydroforming. Thus, the glass transition temperature must be not higher than 120°C, preferably 50°C to 100°C, more preferably 60°C to 90°C.
[0041] In order to improve the adhesion between the resin coating and the steel pipe, before application of the resin, the surface of the steel pipe is preferably acid-cleaned or subjected to blast treatment.
[0042] The resin coating is usually provided on the outer surface of a steel pipe so as to provide good lubrication between dies and the steel pipe in hydroforming, but may also be provided on the inner surface of the steel pipe. Application of the resin onto the inner surface of a steel pipe is primarily intended for rust prevention of the steel pipe before and after hydroforming.
[0043] After the steel pipe coated with the organic resin is hydroformed, the organic resin coating remains on the hydroformed product. Since this coating has a rust-preventive function, the coating may be utilized as a rust-preventive coating. If the inner surface of the steel pipe to be hydroformed is also coated with the organic resin, the inner surface of the hydroformed product will also be prevented from rusting.
[0044] Surface treatment of the steel pipe, which will be described later, provides excellent time-course adhesion between the steel pipe surface and the resin coating. Of course, a hydroformed product may receive finish coating as needed.
[0045] Because the resin can be applied onto a long steel pipe,hydroforming can be started immediately after the

coated long steel pipe is cut into tubular blanks. In other words, the conventional coating and drying steps subsequent to the step of cutting a steel pipe into tubular blanks are not necessary. Also, no extra work to remove adhering paint from end surfaces of tubular blanks in order to establish sealing in hydroforming is necessary.

[0046] When the organic coating is not sufficiently lubricated due to severe hydroforming conditions, the organic coating will preferably contain an organic lubricant (e.g. polyethylene wax or fluoroplastic grains) in an amount of 0.5 wt.% to 20 wt.% in solid term. Also, adding pigments to an organic coating improves adhesion of the coating and increases the hardness of the coating.

[0047] As mentioned previously, additives such as lubricants, pigments, and rust preventives may be added to a resin to control coating performance.

[0048] As lubricants to be added together with other additives, solid lubricants such as wax and metallic soap, are preferred. In order to cope with hydroforming of a high degree of working or difficult hydroforming, metallic soap is particularly preferred because it is adsorbed into the surface of a tubular blank.

[0049] By contrast, inorganic solid lubricants having a large specific gravity are not preferred as they impair the stability of dispersion of a lubricant solution.

[0050] Applicable metallic soap may include esters of fatty acid, phosphoric esters, and sulfuric esters. These kinds of metallic soap are preferably slightly soluble in water. Examples of such metallic soap include Ca salts and Zn salts. K salts and Na salts are not preferred, since they impair the water resistance and corrosion resistance of a coating.

[0051] Metallic soap is added preferably in an amount of 1% to 20% inclusive. When metallic soap is added in an amount of less than 1%, sufficient lubrication is not obtained. When metallic soap is added in excess of 20%, the water resistance of a coating is impaired, and manufacturing performance is also impaired due to foaming at the time of application.

[0052] Hydroforming does not require the inner surface of a tubular blank to be coated with a lubricating resin. When a steel pipe is immersed in a resin solution so as to form a resin coating on the surface thereof, a resin coating is also formed on the inner surface thereof; however, the inner coating has no effect on hydroforming. In the case of a carbon steel pipe, the inner resin coating will prevent the pipe surface from rusting.

(b) Thickness of organic resin coating

[0053] An excessively thin coating is likely to cause scratches in the outer surface of the steel pipe and the galling between dies and the pipe surface. Dies for hydroforming use have a complicated profile of cavity. Accordingly, even when the surface of the die cavity is carefully polished, the maximum surface roughness Rmax is not better than approximately 2 μm. For such a level of surface roughness, the coating thickness must be at least 1 μm. By contrast, when the coating thickness is in excess of 100 μm, a coating tends to exfoliate easily due to an internal stress thereof. Exfoliations of coating adhere to the die surface. Such adhering coating will dimple on the surface of a steel pipe or function as a starting point of buckling in the next hydroforming. Also, economically, an excessively thick coating is wasteful. Accordingly, the thickness of the resin coating is 1 μm to 100 μm, preferably 30 μm to 90 μm, more preferably 30 μm to 50 μm.

[0054] For hydroforming, the resin coating must be relatively thick as described above. Such a thick resin coating may be formed by repeating the application of a resin and drying.

[0055] Since the thickness of the resin coating must be as uniform as possible, the resin is either dissolved in a solvent or water and applied preferably by spraying, or a solid resin is applied preferably by electrostatic spraying a powder of the resin. After the resin dissolved in a solvent or water is applied, forced drying is performed to evaporate the solvent or water. The coated steel pipe may be heated through use of hot air or induction heating. When a radiation curing coating is used, the drying time can for example be reduced through use of ultraviolet rays.

(c) A pre-treatment layer for the resin coating

[0056] A pre-treatment layer is provided as needed. When the deformation resistance or the degree of working of the tubular blank is relatively large, a pre-treatment layer for the resin coating is preferably provided on the steel pipe in order to strengthen the adhesion between the resin coating and the steel pipe.

[0057] A surface treatment layer is provided through phosphate treatment or chromate treatment which is usually applied before coating.

[0058] When the pre-treatment layer is excessively thick, the coating tends to exfoliate easily. Preferably, zinc phosphate is applied in an amount of not greater than 1 g/m^2; iron phosphate is applied in an amount of not greater than 0.3 g/m^2; and chromate is applied in an amount of not greater than 500 mg/m^2 as metallic chromium.

[0059] In phosphating or reactive chromate treatment, the steel pipe is immersed in a treatment solution for a predetermined time and is then washed with water and dried to thereby form a surface treatment layer on the steel pipe. In application type chromate treatment, a treatment solution is sprayed or brushed onto the surface of the steel pipe,

followed by forced drying at a temperature of about 100°C.

(d) Steel pipe

[0060] Examples of material for the steel pipe include, but are not limited to, carbon steel, austenitic stainless steel, and ferritic stainless steel.

[0061] Surface-treated steel pipes of this invention are suitable for hydroforming various steel components used in automotive body such as lower arms,suspension members ,center pillars and so on.

Example 1:

[0062] Fourteen (14) seam welded steel pipes (outer dia. 89.1 mm, thickness 4.2 mm, length 5.5 m) manufactured from hot-rolled steel strip (carbon steel: C 0.05%, Si 0.1%, Mn 0.25%) were acid cleaned and were then coated with an acrylic thermosetting coating material through use of a spray. The 14 steel pipes were coated in different thicknesses. Then, the thus-coated steel pipes were heated for about 5 minutes so that a maximum temperature of 150°C was reached, thereby curing the coatings. As a result, 14 kinds of surface-treated steel pipes whose coating thicknesses ranging from 0.5 µm to 137 µm as shown in Table 1 were obtained.

[0063] The glass transition temperature of coating was found to be 35°C to 110°C as a result of measurement of viscoelasticity. The pencil hardness of the coating was 3H.

[0064] These coated steel pipes were cut into tubular blanks, each having a length L_0 (Fig. 3A) of 300 mm. Each of the thus-obtained tubular blanks was set in the dies of a hydroforming machine. Next, as shown in Fig. 3B, a hydraulic fluid (an emulsion prepared by mixing water with rust preventive oil in a concentration of 3%) was injected into the tubular blank. Thereafter, as shown in Fig. 3C, the tubular blank was axially compressed, while a maximum internal pressure of 500 kgf/cm^2 was applied thereto, to thereby hydroform the tubular blank. The target dimensions of a semifinished product 9 shown in Fig. 3D are as follows: a trunk (9a) has an outer diameter (D1) of 89.1 mm and a length (L') of 180 mm; and a projected portion (9b) has an outer diameter (D2) of 89.1 mm and a height (H') of 65 mm. For each coating thickness, 10 tubular blanks were continuously hydroformed.

[0065] The thus-obtained T pieces were examined for cracking, scratches, and the exfoliation of a resin coating. The results are shown in Table 1.

Table 1

Sample No.	Type of coating	Glass transition temp. °C	Coating thickness (microns)	Hydroformed products suffering defects			Remarks
				Cracking (occurrences)	Scratches (occurrences)	Exfoliation of coating (occurrences)	
1-1	Acrylic	110	0.5*	5	10 (major)	10	Com. Example
1-2	Acrylic	110	1	0	10 (minor)	0	Example
1-3		"	4	0	0	0	
1-4		"	12	0	0	0	
1-5		"	28	0	0	0	
1-6		"	71	0	0	0	
1-7		"	95	0	0	0	
1-8		40	31	0	8 (minor)	0	
1-9		60	35	0	0	0	
1-10		80	29	0	0	0	
1-11		90	32	0	0	0	
1-12		120	35	0	0	2 (minor)	
1-13	Acrylic	110	108*	0	0	2	Com. Example
1-14		"	137*	0	0	10	

*: Outside the range of the present invention

[0066] In the Comparative Example having a thin coating thickness of 0.5 μm (No. 1-1), cracking as shown in Fig. 5 frequently occurred. Also, since noticeable scratches were formed on the outer surface of a hydroformed, semifinished product, the dies had to be polished after three of 10 hydroforming processes.

[0067] By contrast, in the Comparative Examples having a thick coating thickness in excess of 100 μm (Nos. 1-13 and 1-14), a coating exfoliated, so that the dies had to be cleaned each time exfoliation of coating occurred. Also, since exfoliations of coating caused dimple defects to be formed in the surfaces of tubular blanks, the outer surfaces of semifinished products had to be polished through use of a grinder.

[0068] For a coating thickness ranging from 1 μm to 100 μm (No. 1-2 to No. 1-12), semifinished products were all non-defective. T pieces were obtained from them by the following machining: the projected portion 9b of the semifinished product 9 shown in Fig. 3D was cut to a height H of 41.2 mm, and the ends of the trunk 9a were cut away to obtain a length L (Fig. 1) of 171.4 mm. As seen from the above results, an appropriate thickness of an acrylic coating ranges from 1 μm to 100 μm.

Example 2:

[0069] Eleven (11) seam welded steel pipes (outer dia. 89.1 mm, thickness 4.2 mm, length 5.5 m) manufactured from hot-rolled steel strip (carbon steel: C 0.05%, Si 0.1%, Mn 0.25%) were acid cleaned and were then coated with an aqueous urethane coating material through use of a spray. The steel pipes were coated in different thicknesses. Then, the thus-coated steel pipes were heated to a temperature of about 100°C through use of hot air, thereby drying the coatings. As a result, the steel pipes whose coating thicknesses ranged from 0.3 μm to 49.2 μm as shown in Table 2 were obtained. The glass transition temperature of the coating was 80°C. The pencil hardness of the coating was H.

[0070] Hydroforming was performed in a manner similar to that of Example 1 to evaluate formability. The results are shown in Table 2.

Table 2

Sample No.	Type of coating	Glass transition temp. °C	Coating thickness (microns)	Hydroformed products suffering defects			Remarks
				Cracking (occurrences)	Scratches (occurrences)	Exfoliation of coating (occurrences)	
2-1	Urethane	80	0.3*	8	10 (major)	10	Com. Example
2-2		"	0.8*	3	10 (major)	0	
2-3	Urethane	80	1.5	0	10 (minor)	0	Example
2-4		"	3.5	0	0	0	
2-5		"	7.8	0	0	0	
2-6		"	12.5	0	0	0	
2-7		"	25.1	0	0	0	
2-8		"	37.9	0	0	2	
2-9		"	49.2	0	0	0	
2-10		90	1.5	0	10 (minor)	0	
2-11		120	1.5	0	8 (minor)	5 (minor)	

*: Outside the range of the present invention

[0071] For a coating thickness of 0.3 μm and 0.8 μm, 10 tubular blanks failed to be properly hydroformed. For a coating thickness of 1.5 μm, minor scratches were observed on the surfaces of 10 hydroformed products, which, however, were properly hydroformed.

[0072] As seen from the above results, when a urethane resin coating has a thickness of not less than 1 μm, hydroforming is enabled.

Example 3:

[0073] 9 seam welded steel pipes (outer dia. 89.1 mm, thickness 4.2 mm, length 5.5 m) manufactured from hot-rolled steel strip of carbon steel (C 0.05%, Si 0.1%, Mn 0.25%) having a thickness of 4.2 mm and from hot-rolled steel strip of austenitic stainless steel (Cr 18%, Ni 8%) were acid cleaned. Stainless steel pipes further underwent blast treatment. Some of these steel pipes were coated with a resin through use of a spray without subjecting to chromate treatment, and the remaining steel pipes were chromate-treated and then coated with a resin.

[0074] Resins used, the thickness of a resin coating, and the amount of applied chromate are shown in Table 3.

[0075] These coated steel pipes were cut into tubular blanks, each having a length L_0 (Fig. 3A) of 300 mm. Each of the thus-obtained tubular blanks was set in the dies of a hydroforming machine. Next, as shown in Fig. 3B, a hydraulic fluid (an emulsion prepared by mixing water with rust preventive oil in a concentration of 3%) was injected into the tubular blank. Thereafter, as shown in Fig. 3C, the tubular blank was axially compressed, while a maximum internal pressure of 700 kgf/cm^2 was applied thereto, to thereby hydroform the tubular blank.

[0076] The target dimensions of a semifinished product 9 shown in Fig. 3D are as follows: a trunk (9a) has an outer diameter (D1) of 89.1 mm and a length (L') of 180 mm; and a projected portion (9b) has an outer diameter (D2) of 89.1 mm and a height (H') of 65 mm.

[0077] For each of samples Nos. 3-1 to 3-9, 10 tubular blanks were continuously hydroformed.

[0078] The thus-obtained T pieces were observed for cracking, scratches, and the exfoliation of a resin coating. The results are shown in Table 3.

Table 3

Sample No.	Material of steel pipe.	Type of coating	Amount of applied chromate (mg/m2*)	Coating thickness (microns)	Hydroformed products suffering defects			Remarks
					Cracking (occurrences)	Scratches (occurrences)	Exfoliation of coating (occurrences)	
3-1	Carbon steel	Polyester	11	1.5	0	0	0	Example
3-2		Acrylic	11	1.5	0	0	0	
3-3		Urethane	11	1.5	0	0	0	
3-4	Stainless steel	Polyester	0	1.5	0	10(minor)	0	
3-5		〃	0	7.8	0	0	0	
3-6		〃	11	1.5	0	0	0	
3-7		〃	490	1.5	0	0	0	
3-8		Acrylic	11	1.5	0	0	0	
3-9		Urethane	11	1.5	0	0	0	

[0079] For samples No. 3-4 having a resin coating thickness of 1.5 μm and having no chromate coating, scratches were somewhat formed, but were to such a degree as not to affect actual use. For chromate-treated samples Nos. 3-1 and 3-6 having a resin coating thickness of 1.5 μm did not suffer any scratches, indicating the effect of chromate treatment.

Claims

1. Use of a lubricant surface-treated steel pipe in hydroforming, which steel pipe comprises a lubricating organic resin coating provided on at least an outer surface of the steel pipe, wherein the resin has a glass transition temperature of 40 °C to 120 °C and is selected from thermosetting or radiation curing type resins and wherein the coating has a thickness of 1μm to 100 μm.

2. Use of a steel pipe according to claim 1 wherein the resin is selected from acrylic, urethane, polyester and epoxy resins.

3. Use of a steel pipe according to claim 1 or 2, wherein the lubricating organic resin coating is provided on a pre-treatment layer which is provided on at least an outer surface of the steel pipe.

4. Use of a steel pipe according to any one of claims 1 to 3, wherein the thickness of the organic resin coating is from 30μm to 90μm.

5. Use of a steel pipe according to any one of claims 1 to 4, wherein the organic resin coating comprises polyethylene wax or fluoroplastic grains as an organic lubricant in an amount of from 0.5% to 20% by weight.

6. Use of a steel pipe according to any one of claims 3 to 5, wherein the pre-treatment layer is zinc phosphate applied in an amount of not greater than 1 g/m^2.

7. Use of a steel pipe according to any one of claims 3 to 5, wherein the pre-treatment layer is iron phosphate applied in an amount of not greater than 0.3 g/m^2.

8. Use of a steel pipe according to any one of claims 3 to 5, wherein the pre-treatment layer is a chromate applied in an amount of not greater than 500 mg/m^2 as metallic chromium.

Patentansprüche

1. Anwendung eines mit Gleitmittel oberflächenbehandelten Stahlrohrs beim Hydroforming, **dadurch gekennzeichnet, daß** die Außenfläche des Stahlrohrs einen als Gleitmittel wirkenden organischen Harzüberzug aufweist, wobei das Harz eine Glasübergangstemperatur von 40 °C bis 120 °C hat und unter hitzehärtbaren oder strahlungshärtbaren Harzen ausgewählt wird und wobei der Überzug eine Dicke von 1 μm bis 100 μm aufweist.

2. Anwendung eines Stahlrohrs nach Anspruch 1, **dadurch gekennzeichnet, daß** das Harz unter Acryl-, Urethan-, Polyester- und Epoxidharzen ausgewählt wird.

3. Anwendung eines Stahlrohrs nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** ein als Gleitmittel wirkender organischer Harzüberzug auf eine Vorbehandlungsschicht aufgebracht wird, mit der wenigstens eine Außenfläche des Stahlrohrs versehen ist.

4. Anwendung eines Stahlrohrs nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, daß** die Dicke des organischen Harzüberzugs von 30 μm bis 90 μm beträgt.

5. Anwendung eines Stahlrohrs nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, daß** der organische Harzüberzug als organisches Gleitmittel Polyethylenwachs oder Fluorkunststoffgranulat in einer Menge von 0,5 bis 20 Gew.-% enthält.

6. Anwendung eines Stahlrohrs nach einem der Ansprüche 3 bis 5, **dadurch gekennzeichnet, daß** die Vorbehandlungsschicht Zinkphosphat ist, welches in einer Menge nicht über 1 g/m^2 aufgebracht wird.

7. Anwendung eines Stahlrohrs nach einem der Ansprüche 3 bis 5, **dadurch gekennzeichnet, daß** die Vorbehandlungsschicht Eisenphosphat ist, welches in einer Menge nicht über 0,3 g/m^2 aufgebracht wird.

8. Anwendung eines Stahlrohrs nach einem der Ansprüche 3 bis 5, **dadurch gekennzeichnet, daß** die Vorbehandlungsschicht ein Chromat ist, welches in einer Menge nicht über 500 mg/m^2 als metallisches Chrom aufgebracht wird.

Revendications

1. Utilisation d'un tuyau en acier à surface traitée par un lubrifiant pour l'hydroformage, ce tuyau en acier comprenant un revêtement en résine organique lubrifiante disposé sur un moins une surface extérieure du tuyau en acier, la résine ayant une température de transition vitreuse comprise entre 40° C et 120° C et étant sélectionnée parmi des résines du type durcissant aux radiations ou thermodurcissable, et le revêtement ayant une épaisseur comprise entre 1 µm et 100 µm.

2. Utilisation d'un tuyau en acier selon la revendication 1, dans lequel la résine est sélectionnée parmi les résines acryliques, uréthanes, polyesters et époxy.

3. Utilisation d'un tuyau en acier selon la revendication 1 ou 2, dans lequel le revêtement en résine organique lubrifiant est disposé sur une couche de pré-traitement qui est disposée sur au moins une surface extérieure du tuyau en acier.

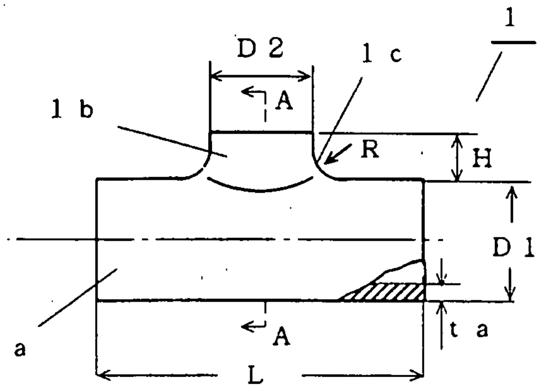
4. Utilisation d'un tuyau en acier selon l'une quelconque des revendications 1 à 3, dans lequel l'épaisseur du revêtement en résine organique est comprise entre 30 µm et 90 µm.

5. Utilisation d'un tuyau en acier selon l'une quelconque des revendications 1 à 4, dans lequel le revêtement en résine organique comprend une cire de polyéthylène ou des grains fluoroplastiques constituant un lubrifiant organique en une quantité comprise entre 0,5 % et 20 % en poids.

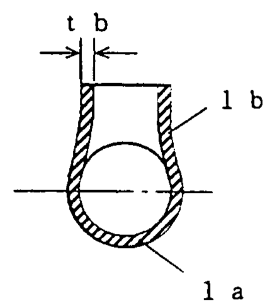
6. Utilisation d'un tuyau en acier selon l'une quelconque des revendications 1 à 5, dans lequel la couche de prétraitement est du phosphate de zinc appliqué en une quantité qui n'est pas supérieure à 1 g/m^2.

7. Utilisation d'un tuyau en acier selon l'une quelconque des revendications 3 à 5, dans lequel la couche de prétraitement est du phosphate de fer appliqué en une quantité qui n'est pas supérieure à 0,3 g/m^2.

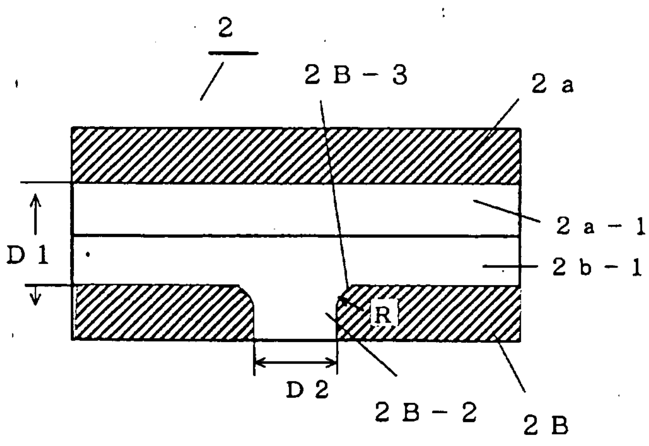
8. Utilisation d'un tuyau en acier selon l'une quelconque des revendications 3 à 5, dans lequel la couche de prétraitement est un chromate appliqué en une quantité qui n'est pas supérieure à 500 mg/m^2 de chrome métallique.



F i g . 1 A



F i g . 1 B



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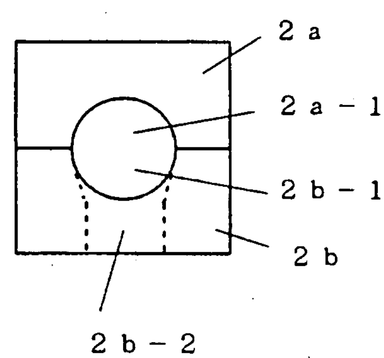


F i g . 2 B

Fig.3A

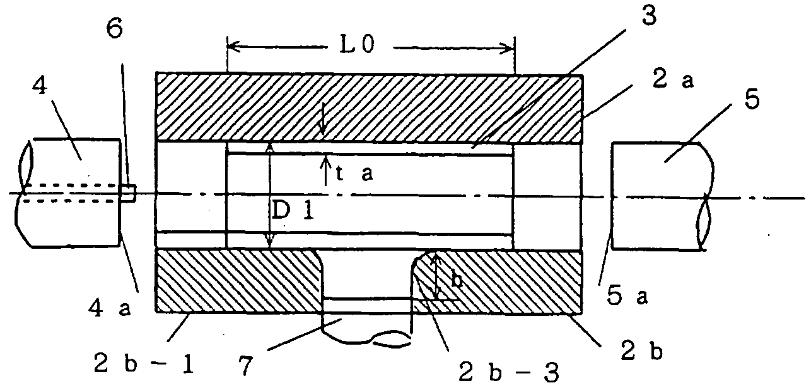


Fig.3B

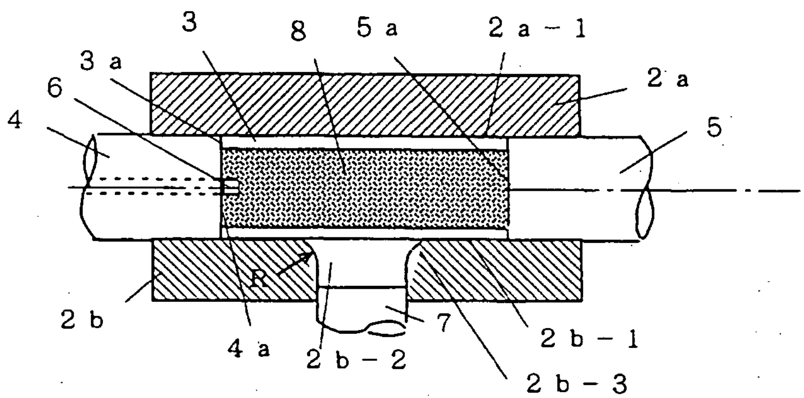


Fig.3C

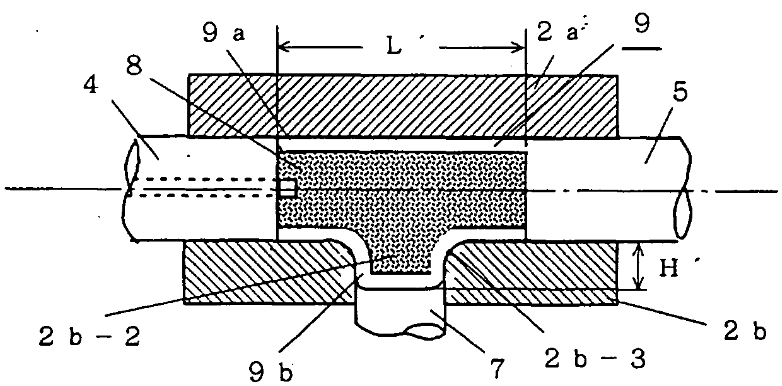
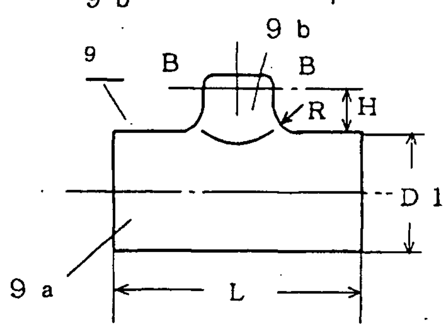


Fig.3D



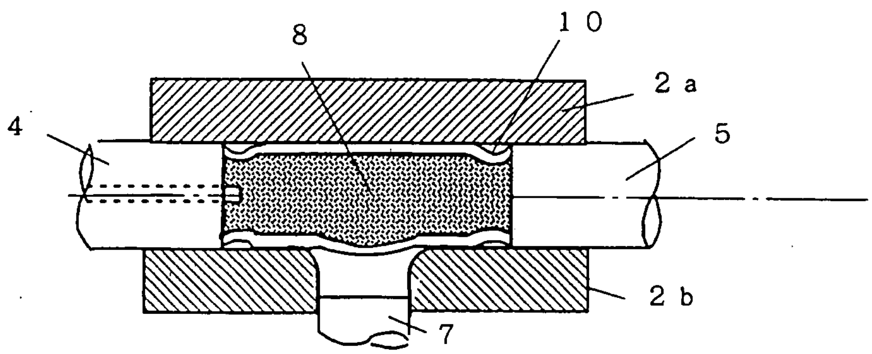


Fig.4

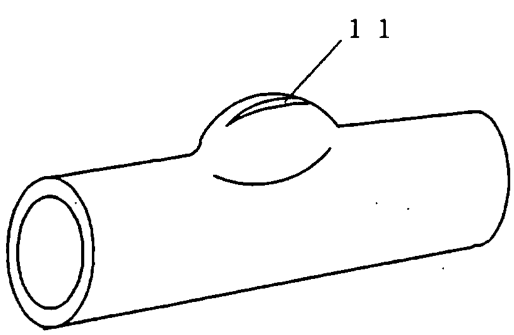


Fig.5